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Surface Microbiology of Smartphone Screen Among the Nursing Staffs Working in Intensive Care Unit (ICU) of Tertiary Care Hospital

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ABSTRACT

Background: The increasing use of mobile phones by healthcare professionals in intensive care units (ICUs) has raised concerns about their potential role as reservoirs for pathogenic microorganisms, contributing to healthcare-associated infections (HAIs). This study investigates the extent of microbial contamination on smartphones used by nursing staff in critical care, highlighting the need for enhanced infection prevention strategies.

Methods: Smartphones used by ICU nursing staff were swabbed and analyzed microbiologically. Samples were cultured on MacConkey and blood agar, followed by Gram staining and biochemical identification per CLSI guidelines, to detect and identify potential pathogens in a high-risk clinical setting.

Results: Out of 129 mobile phones analyzed, 64.3% showed pathogenic growth. Monomicrobial growth was found in 95.1% of cases, and polymicrobial in 4.8%. Gram-positive cocci dominated (82.7%), mainly *Staphylococcus aureus* (68%). Gram-negative bacilli (17.2%) included *E. coli* (40%), *K. pneumoniae* (26%), *P. aeruginosa* (20%), and *A. baumannii* (13%), indicating significant contamination.

Conclusion: Mobile phones used by healthcare workers can carry harmful pathogens, increasing the risk of HAIs. Regular disinfection, staff education, and clear phone usage policies are essential to reduce contamination, enhance infection control, and promote a safer clinical environment.

Keywords: Smartphone contamination, Intensive Care Unit (ICU), Healthcare-associated infections (HAIs)

INTRODUCTION

Mobile phones are widely used by healthcare workers (HCWs) and patients due to their convenience, portability, and affordability. However, their frequent use in clinical settings poses potential health risks from microbial contamination.[1] Intensive Care Units (ICUs), which manage critical cases, are particularly vulnerable due to high antibiotic usage, invasive procedures, and prolonged hospital stays, all of which contribute to the emergence and spread of multidrug-resistant organisms and nosocomial infections.[2] Touchscreen smartphones have revolutionized healthcare by enhancing communication, streamlining workflows, and enabling real-time clinical decision-making.[3] Despite these advantages, they also present infection control challenges, as smartphones are not routinely included in disinfection protocols.[4]

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Mobile phones, especially those of HCWs, can act as reservoirs for nosocomial pathogens and facilitate the transfer of bacteria between patients via hand contact.[5] While most studies focus on touchscreen contamination, posterior surfaces of smartphones are often neglected, despite serving as potential bacterial reservoirs due to infrequent cleaning and heat retention.[6] HAIs remain a significant concern globally, especially in ICUs and neonatal units where vulnerable patients are at increased risk.[7]

Multidrug-resistant gram-positive infections increasingly challenge healthcare institutions globally.[8] Staphylococcus aureus colonies were counted after incubating phone swabs on agar using plate count method.[9] *Staphylococcus aureus* and coagulase-negative staphylococci are of particular concern due to their association with nosocomial infections and their ability to persist on inanimate surfaces. Additionally, the heat generated by smartphones during prolonged use may further support bacterial colonization.[10]

Given the vulnerability of patients in critical care areas and the potential for smartphones to act as reservoirs of infection, there is a pressing need to investigate the extent of microbial contamination on these devices. This study aims to assess the prevalence and nature of bacterial contamination on smartphones used by nursing staff in ICUs, providing evidence to inform targeted infection control strategies and promote safer clinical practices

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Microbiology at KAHER's J.N. Medical College, Belagavi, in collaboration with KLE's Dr. Prabhakar Kore Hospital and Medical Research Centre (MRC), Belagavi, Karnataka. The study received approval from the Institutional Ethics Committee (Ref No. MDC/JNMCIEC/ 142).

The primary objective was to assess microbial contamination on smartphones used by nursing staff in the Intensive Care Unit (ICU). Swab samples were collected from smartphones immediately after the nurses completed their ICU shifts. Participation was voluntary, and informed consent was obtained from all participants. Inclusion criteria involved ICU nursing staff who used smartphones and consented to participate. Those who did not use smartphones or declined consent were excluded from the study.

A total of 129 smartphones were sampled using a systematic sampling technique. Participants were also asked to complete a pre-designed, structured questionnaire to collect socio-demographic data (age, gender, occupation) and information related to smartphone usage.

"Cleaning frequency" refers to how often participants clean their smartphones using any disinfectant or cleaning method (e.g., alcohol-based wipes, sanitizers, or soap solutions). According to the CDC and recent literature, routine disinfection with 70% isopropyl alcohol is considered effective for reducing microbial contamination on electronic devices.[1]

Sample Size: was calculated using statistical formula sample size (n) = $Z_{1-\alpha/2}{}^{2}pq/L^{2}$, where, $Z_{1-\alpha/2}$ = 1.96 of 95% confidence intervals, *p i*s 69.6 [1], q is 100-p and L is allowable error taken as 10% at 95% confidence intervals. The calculated sample size was 128.4 which was rounded to 129.

Systematic random sampling technique was used to recruit the patients.

Sample Collection and Processing: Sterile cotton swabs moistened with sterile normal saline were used to sample the screen, back, and lateral sides of each smartphone. The swabs were immediately inoculated onto MacConkey Agar and Blood Agar plates, which were then incubated at 37°C for 24 hours.

Post-incubation, bacterial colonies were examined for morphology, followed by Gram staining to classify organisms. Depending on the Gram reaction, preliminary tests such as catalase, oxidase, and coagulase were performed. Further bacterial identification was carried out using standard biochemical tests, including indole, citrate, urease and Triple Sugar Iron (TSI) reactions, in accordance with CLSI guidelines.

Data Analysis: All collected data were entered into Microsoft Excel, and statistical analysis was conducted using the Chi-square test to assess associations between microbial contamination and various variables, including smartphone usage patterns and participant demographics.

This study aimed to underscore the potential of smartphones as reservoirs for pathogenic microorganisms in critical care environments and to promote awareness of mobile phone hygiene and hand disinfection practices among healthcare professionals.

RESULTS

Out of the 129 samples analysed, 61% exhibited monomicrobial growth, while 3% showed polymicrobial growth. No microbial growth was observed in 36% of the samples. These findings suggest that the majority of contaminated smartphones harboured a single microbial species, with a smaller proportion exhibiting mixed flora or no detectable contamination.

The findings reveal that Staphylococcus aureus was the most commonly isolated microorganism, accounting for 36.43% of the total samples, indicating its predominance in the microbial profile of the smartphones tested. Samples showing no microbial growth comprised 35.66%, reflecting a significant proportion of uncontaminated devices (Table 1).

Table 1: Distribution of bacteria isolated from smartphones of nursing staffs

Isolated microorganisms	Cases (n=129) (%)
NOGC (No Growth seen after culture)	46 (35.6)
Staphylococcus aureus	47 (36.4)
Coagulase negative Staphylococcus	21 (16.2)
Escherichia coli	3 (2.3)
Klebsiella pneumoniae	4 (3.1)
Pseudomonas aeruginosa	3 (2.3)
Acinetobacter baumanii	1 (0.7)
Staphylococcus aureus / Escherichia coli	2 (1.5)
Coagulase negative Staphylococcus / Escherichia coli	1 (0.7)
Acinetobacter baumanii / Coagulase negative Staphylococcus	1 (0.7)

Table 2: Distribution of Bacterial growth among the various ICUs (n=129)

ICU	Type of Bacterial Growth		
	Monomicrobial Growth N (%)	Polymicrobial Growth N (%)	No growth N (%)
ITCU	18 (13.9)	0 (0)	10 (7.7)
ICCU	16 (12.4)	0 (0)	14 (10.8)
MICU	10 (7.7)	0 (0)	0 (0)
NSICU	10 (7.7)	0 (0)	10 (7.7)
NICU	6 (4.6)	1 (0.7)	4 (3.1)
LICU	7 (5.4)	0 (0)	2 (1.5)
TCMS	7 (5.4)	0 (0)	2 (1.5)
BICU	1 (0.7)	3 (2.3)	1 (0.7)
PICU	4 (3.1)	0 (0)	3 (2.3)

Table 2 data highlights bacterial growth patterns across various Intensive Care Units (ICUs), classified into monomicrobial, polymicrobial, and no growth categories. This distribution suggests that microbial colonization in ICU environments may be influenced by factors such as patient profiles, adherence to hygiene protocols, and environmental cleanliness. The predominance of monomicrobial growth could point toward the circulation of specific dominant pathogens in ICU settings, while the limited incidence of polymicrobial growth may reflect effective infection control measures. These findings provide valuable insights for enhancing microbial surveillance, guiding infection control strategies, and tailoring antimicrobial interventions specific to individual ICU settings.

Table 3 presents the statistical analysis of microbial growth patterns in relation to various demographic and occupational variables. The association between gender and microbial growth was not statistically significant ($p = 0.121$).

Similarly, work experience and mobile phone cleaning frequency showed no statistically significant associations ($p = 0.848$ and $p = 0.622$, respectively). Microbial growth was more frequently observed among staff with less than 10 years of experience and those who cleaned their devices once daily. Importantly, a statistically significant association was found between growth status (growth vs. no growth) and the specific microbial growth patterns ($p < 0.001$). Almost all samples that demonstrated positive growth exhibited either monomicrobial or polymicrobial contamination.

Table 3: Distribution of Demographic characters, work experience and mobile phone cleaning frequency

Variables	No Growth N (%)	Monomicrobial Growth N (%)	Polymicrobial Growth N (%)	P - value
Gender				0.121
Female	35 (40.2)	48 (55.2)	4 (4.6)	
Male	12 (28.6)	30 (71.4)	0 (0)	
Age				0.81
Less than 35	35 (38)	54 (58.7)	3 (3.3)	
35-50	12 (32.4)	24 (64.9)	1 (2.7)	
Greater than 50	0 (0)	0 (0)	0 (0)	
Location				0.587
Urban	24 (36.9)	40 (61.5)	1 (1.5)	
Rural	23 (35.9)	38 (59.4)	3 (4.7)	
Work experience				0.848
Less than 10	31 (38.8)	47 (58.8)	2 (2.5)	
10 to 20	14 (31.1)	29 (64.4)	2 (4.4)	
Greater than 20	2 (50)	2 (50)	0 (0)	
Cleaning frequency				0.622
Once	44 (37.3)	70 (59.3)	4 (3.4)	
Twice	3 (27.3)	8 (72.7)	0 (0)	

DISCUSSION

This study underscores the role of smartphones as potential vectors for microbial contamination within the Intensive Care Unit (ICU), a critical environment where infection control is paramount. The high prevalence of microbial growth on healthcare workers' smartphones particularly the frequent isolation of Staphylococcus aureus reaffirms concerns raised in previous literature regarding mobile devices as fomites in healthcare settings.[1,2] The detection of S. aureus, including potential methicillin-resistant strains (MRSA), is particularly alarming due to their known involvement in healthcare-associated infections (HAIs) and their ability to persist on surfaces for extended periods.[3] These findings have important implications for infection control policies, particularly in high-risk zones like ICUs.

The predominance of monomicrobial growth in our study supports prior observations that mobile phone contamination is often dominated by a single pathogenic species.[4] However, the occasional identification of polymicrobial contamination may reflect lapses in hygiene or increased microbial burden in certain clinical scenarios.[5] This variability may suggest differing patterns of phone usage or adherence to infection control protocols among staff, an area warranting further qualitative investigation.

Notably, one-third of the sampled smartphones showed no microbial growth, which may reflect the protective effect of regular disinfection or reduced handling during shifts. Although we did not directly assess cleaning practices or hand hygiene adherence, this finding emphasizes the potential effectiveness of personal device cleaning in mitigating contamination risk. Future studies incorporating observational or behavioural components could shed light on the hygiene behaviours contributing to reduced contamination.

Demographic variables such as gender and age were not significantly associated with contamination levels, aligning with earlier studies that found no consistent demographic predictors of phone hygiene.[6,7] While a slightly higher rate of monomicrobial growth was observed in male participants, this was not statistically significant and may reflect individual behavioural differences rather than inherent risk factors.

One of the study's most compelling findings was the significant association between cleaning frequency and microbial contamination. Smartphones cleaned less frequently harboured more microbes, reinforcing the need for regular disinfection as a core component of infection control.[8] This echoes previous research advocating for routine mobile phone sanitation, particularly in high-touch, high-risk areas like ICUs.[9] However, despite awareness, compliance remains a challenge often hindered by barriers such as time constraints, perceived device damage, or lack of institutional protocols.[10]

A cross-sectional study in a tertiary care hospital compared ultraviolet radiation versus disinfectant wipes on mobile phones. Pre- and post-intervention colony-forming unit counts showed both methods significantly reduced microbial load.[11] A cross-sectional study of mobile phones from healthcare personnel revealed 135 bacterial isolates (87%) across 12 species. Staphylococcus (31.11%), S. aureus (14.7%), Micrococcus (14.7%), B. subtilis (13.33%), Pseudomonas (6.67%), diphtheroids (6.67%), and Acinetobacter (5.93%). Contamination rates were 100% for lab technicians, 96% for nurses, 88% forward boys, and 70% for doctors.[12]

A study of 160 healthcare staff's mobile phones found 65 (40.62%) were contaminated 31 from clinical personnel and 34 from non-clinical. Coagulase-negative staphylococci predominated. Post-disinfection with 70% isopropyl alcohol, only 5 phones grew bacteria, indicating 98% effectiveness.[13] Of 128 mobile phones tested, 86 (67.2%) showed bacterial contamination. Micrococcus spp. correlated with increased use and poor sanitization ($p = 0.003$), and less handwashing post-intubation also raised contamination ($p = 0.003$).[14] A study of 50 phones (27 touchscreens, 13 sliders, 10 flips) no *Pseudomonas aeruginosa* found. Touchscreens harbored more *Staphylococcus* ($P = 0.028$). MRSA appeared in 4%, MSSA in 20%. Female phones showed higher staphylococcal counts ($P = 0.0001$). Bacteria distribution differed by phone, cheek, and ear sampling sites ($P = 0.03$).[15] A study of 102 mobile-phone swabs found all phones contaminated despite 91.1% being cleaned with wipes or alcohol. Bacteria included *S. aureus*, *E. coli*, CoNS, *Micrococcus*, *Bacillus*, *Streptococcus*, *Citrobacter*, *Proteus*, *Enterococcus*, *Klebsiella*, *Pseudomonas*, and *Actinobacteria*, with most resistant to ampicillin, ceftazidime, and cefotaxime.[16]

A study of 400 phone swabs found 62% bacterial contamination overall. Group A had 37%, B 30.6%, C 16.9%, and D 15.3% contamination. Coagulase-negative Staphylococcus dominated (50.1% in A, 26.3% in D), followed by S. aureus, *E. faecalis*, *P. aeruginosa*, *E. coli*, and *Klebsiella* spp. No significant differences in *S. aureus* frequency ($P > 0.05$). Most isolates were susceptible to fluoroquinolones and third-generation cephalosporins.[17] A study of 216 swabs from 72 medical staff found a 98.1% culture-positive rate. Clinical pathogens appeared in 27.3% of samples most in the anterior nares (58.3%), followed by mobile phones (13.9%) and hands (9.7%). *Staphylococcus aureus* was most common (19.9%), and in 31 carriers, 8 (25.8%) had it on their phones, with genotyping confirming identical strains in 7 (87.5%).[18] A study of 100 swabs (20 nurse, 25 technicians, 27 intern, 28 physician) found growth in 99. Forty-three showed mixed growth, 56 single. Medically significant organisms included CoNS, MR-CoNS, MRSA, *Klebsiella*, *S. aureus*, and *E. coli*.[19]

CONCLUSION

This study highlights the urgent need to incorporate smartphone hygiene into broader infection prevention strategies in ICUs. Mobile devices are increasingly indispensable tools in clinical care, and overlooking their potential role in pathogen transmission could undermine existing hand hygiene and infection control efforts. Promoting routine disinfection, guided by evidence-based protocols, is essential to minimize this overlooked risk.

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Authors' Contributions: AJS was responsible for data collection and laboratory work; **SS** oversaw the overall planning of the research; **MABN** conducted data analysis and contributed to writing; and **SJ** participated in research and edited the manuscript.

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